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ANALYSES OF SOME HEAVY METAL AND NUTRIENTS OF WATER SAMPLES FROM AJEGUNLE CREEK IN LAGOS

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ABSTRACT: *This study investigates level of pollution in the Ajegunle Creek. Water samples were collected and analyzed for five months. This physicochemical characteristics, cation content, nutrients and heavy metal levels varied across the three sampled stations. The mean physicochemical parameters are Temperature (23-29.5°C), TSS (9-43mg/l), TDS (386.3-15700mg/l), Turbidity (4.92-34.02NTU), Salinity (0.53-8.9%), Conductivity (679.3-25900 µS/cm), DO (0.1-4.8mg/l), BOD_5 (2-598mg/l), COD (10-2192mg/l), Total Hardness (82-972mg/l). There were variations in the nutrient values. The mean cation content was; potassium (3.62-151mg/l), Calcium (4.11-170.3mg/l), Silica (0.82-11.43mg/l), Sodium (135.1-4926.07mg/l) and Oil and grease (< 0.2 mg/l). Nitrate ion is the common form of nitrogen found in the study site. The metals concentrations recorded are arranged in order of their distributions in the three sampling stations as follows: Fe>Zn>Mn>Cr>Ni>Cd>Pb>Cu. The seasonal influence as well as human induced stressors in the water confirmed that the Ajegunle creek in the Tin-Can Island area of Lagos is polluted.*

KEYWORDS: heavy metal, physicochemical quality and nutrients creek

INTRODUCTION

Nigerian aquatic environment is a serious and growing problem with increasing numbers/amounts of industrial, agricultural and commercial chemicals discharged into the aquatic environment led to various deleterious effects on aquatic organisms (Li *et al.*, (2020). Aquatic organisms, including fish, accumulate pollutants directly from contaminated water and indirectly *via* the food chain. Disposal of sewage wastes into a large volume of water could increase the biological oxygen demands to such a high level that all the available oxygen may be removed, consequently causing the death of all aerobic species, e.g., fish (Nath and Sengupta, 2016). Creeks are important sites of habitation providing assets of both land and sea as they serve as spawning, breeding and nursery grounds for array of aquatic resident and migratory biota (Nwankwo and Akinsoji, 1989). According to Adesalu and Nwankwo (2008), there are two types of creeks associated with the Nigerian coastal environment: the tidal freshwater creeks which are surrounded partly by mangrove swamps and partly by freshwater swamps while the non-tidal creeks are surrounded by freshwater. The maintenance of aquatic ecosystem is totally dependent on the physicochemical properties and biological diversity which are affected by the prevailing anthropogenic activities

(Verkatesharajlu *et al*., 2010). There is no previous in-depth study of some metals in of the Ajegunle Creek of the Tin-can Island area of Lagos State, its physicochemical regime, the extent and effects of the various anthropogenic stressors to which the creek and its biological resources are exposed to. The evaluation of the effects of monthly fluctuation of the heavy metals and the physicochemical parameters at the Ajegunle Creek of the Tin-can Island area of Lagos would provide useful evidence of the impact of domestic wastes, agricultural runoffs and chemical effluents from the surrounding industries in the creek. Hence, there is great need for gross understanding of the nature and dynamics of the Ajegunle Creek

LITERATURE/THEORETICAL UNDERPINNING

Water is typically referred to as polluted when it is impaired by anthropogenic contaminants and either does not support human use or undergoes a marked shift in its ability to support its constituent biotic communities (Newton, 2008). Water pollution affects plants and organisms living in these bodies of water, causes major changes in water quality and the ecological status of water (Nwaedozie, 2000). In almost all cases, the effect is damaging not only to individual species and populations, but also to the natural biological communities and consumers (Newton, 2008).
The type of activities prevalent in any given environment determines the type of contamination in that area (Andem *et al*., 2012). The water in a particular area may have been sinks for many hazardous wastes, organic wastes, sewage and several other waste types generated from different human activities (Nwuko, 2014). In most cases, heaps of wastes are left in the trail of excavations for minerals and rains wash the waste heaps into the surrounding water bodies and farmlands, the creeks overflow their banks resulting in pollution even outside the area of production. Investigations of anthropogenic wastes and environmental modifications in the Lagos lagoon, Nigeria as reported by Edokpayi and Nkwoji (2007) revealed increased levels of pollution stress due to influx of polluted water from the creeks. Nwankwo (2004) had earlier reported that the implication of increasing population pressure, poor sewerage system, industrialization and poor waste management in Nigerian's coastal areas is that pollutants freely find their ways into the coastal waters through drains, canals, rivers, creeks and lagoons that act as conduits. Moreover, apart from enriching the water with high amounts of biodegradable matter, these discharges introduce nutrients, toxic and other land-based substances that may consequently signal epidemiological problems and an increase in human induced stressors which impairs aquatic biodiversity (Nwankwo and Akinsoji, 1988).

It is dominated by effluence such as industrial and municipal waste discharges, fertilizers and pesticides from agricultural soils, chemical leakages from landfills/waste disposal pits, leaching of animal and human wastes, human activities like fishing, human and goods transportation, dredging, sand mining, mangrove cutting and cases of oil pollution arising from accidental spillages (Idera, *et al.*, 2015). These activities, affect the physical and chemical characteristics of these creeks most noticeable is the reduction of plankton as reported by Onyema (2013). According to Chen, *et al*. (2020), water quality degradation has become an important issue around the world. Onyema (2007) reported that the creeks and lagoons of south-western Nigeria, apart from their ecological and economic significance, serve as sink for the disposal of an increasing array of waste types. Saliu and Ekpo (2006) submitted that creeks are valuable part of the aquatic resources serving as Feeder Rivers, providing flood control, storm water drainage, habitat to wildlife, creating neighbourhood beauty and improving quality of life but there has been a systematic loss of creeks due to overuse, pollution, diversion or filling in developing countries like Nigeria.

Wastes pose serious threat to associated environment including human health risks as they are discharged into inland water bodies. Yusuf and Osibanjo (2006) asserted that the quality of surface water bodies in Nigeria is gradually deteriorating. In this regard and related instances however, surface water pollution become obvious when the self-cleansing or the pollutant carrying capacities of the water is exceeded (Chakrabarty, 2020)

MATERIALS AND METHOD

The Ajegunle, creek is located around the Tin-can Island area, Lagos state; it empties into the Badagry creek into the Lagos lagoon. It is open throughout the year, receives tidal influences which are experienced far inland especially during dry season from the lagoon. The Creek is a shallow tidal creek that experienced semi-diurnal tidal oscillations and is located at an elevation of 36metres above sea level at latitude of 6° 28' 21" N (6.4725°); Longitude: 3° 22' 20" E (3.3722°) and elevation: 4 metres (13 feet). The creek is a stream (class H-Hydrographic) and has a unique S-curve shape waterway channel. These tidal influences and their effects are minimal during the wet season and at this time fresh water life predominates such as the presence of mangrove trees etc. The creek is characterised by floating plants such as Pistia and an abundance of water hyacinth *Vassia racemosa* and (*Eichishoria crassipes*). Further downstream from the stations are *Rhizophora racemosa* (Red mangrove), *Acrostiscum aureum* (Halophytic fern), *Paspalum vaginatum, Phoenix reclinata, Cyperus* articulates are common macro floras found along the edges and shore zone of the water ways.

The creek is marked by the presence of high rate of pollution from surrounding residents which is evident by the large amount of refuse deposited at the banks of the creek and sewage floating on the water surface into which toilets and bathrooms have been constructed. The axis serves as a major drainage channel for the area, receiving domestic wastes discharges from houses with non-existing or poor sewerages, solid wastes used as landfill materials in the area, land reclamation, fishing activities and refuse disposal are all common practices. The colour of the water appearing green and dark brown is as a result of various environmental and anthropogenic influences in the region thereby reducing transparency and leading to low productivity and eutrophication.

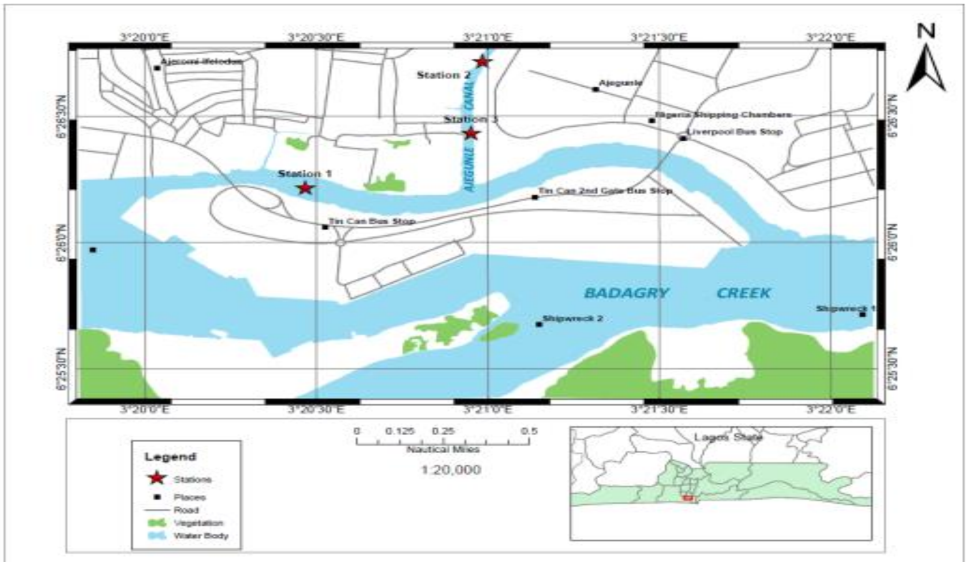

Figure 1: Map showing the studied stations in the Ajegunle, creek around the Tin-can Island area

DETERMINATION OF PHYSICOCHEMICAL PARAMETERS

Collection of Water Samples

The sampling stations were sampled once a month for five (5) months. Water samples were collected each time using 75cl plastic containers well labeled to indicate the month of collection at the study site. Sampling was carried out between 10.00 and 12.00 hours each day. water samples were taken to the laboratory for physicochemical analysis and heavy metals analysis.

Determination of Physicochemical Parameters

pH

The pH values were determined by the Electrometric Method using the Cole Parmer Test. The pH meter was calibrated and standardized. Three pH buffers (pH 4.0, 7.0, and 10.0) were used for the calibration. Each sample pH was determined at 26°C with the calibrated water and immersing the probe into the water sample.

Salinity (‰)

Salinity was determined using Saline Test Salinity Meter (Hanna Instrument HI 98203). The calibration standard prepared from reagent grade (1.0, 5.0, 10.0, 20.0, 50.0g). Nacl was separately weighed and dissolved separately in distilled water. The final volume of each set then adjusted to 1Litre with distilled water. The meter was calibrated by immersing into solution and taking reading after a few seconds when display stabilizes. Once it is calibrated, each sample was determined similarly by immersing the probe and taking reading in parts per thousand (‰).

Water Temperature (^{0}C)

The surface water temperature was determined in-situ using mercury-in glass thermometer. This is done by collecting 200ml of water from the surface at the site with a plastic container and dipping the thermometer into it for two minutes for acclimatization before taking the reading. The temperature is read off the eye level and the value recorded in degree Celsius (^{0}C)

Alkalinity (mg/L)

The alkalinity was determined using the Titration Method 2320B. Alkalinity of water is its acid neutralizing capacity. It is the sum of all titratable bases. An appropriate volume of the sample was titrated against standard acid of p- and m- alkalinities, using specific indicators. The end-point was recorded and used to determine the alkalinity using the equation below. All values were expressed in mg/L.

$$A\text{lkalinity as CaCO}_3\left(\frac{\text{mg}}{\text{L}}\right) = \frac{\text{Titre (ml)x Molarity x 50,000}}{\text{Aliquot titrated (ml)}}$$

Conductivity (µS/cm)

This is determined by using Philips PW9505 Conductivity Meter (Range 3-100,000µ S/cm). Conductivity standards were prepared from traceable commercial standards. The following standards were used: conductivity standard equivalent to 100, 255, 500, 1000, 20,000µS/cm. Calibration standards with conductivity value close to those of the samples were used to calibrate the meter before sample determination. The sample conductivity was determined by immersing the probe into a portion of the sample. Each sample reading was expressed in mg/L.

Dissolved Oxygen (DO) (mg/L)

The Dissolved Oxygen was estimated by Titrimetric (Iodometric) Method using the Azide Modification procedure 4500^{0}C. The method involves the addition of divalent manganese solution followed by strong alkali, to the sample in a glass-stoppered bottle. DO rapidly oxidize an equivalent amount of dispersed divalent manganous hydroxide precipitate to hydroxides. To the sample in 100ml DO bottle was added two drops of $MnSO_4$ solution followed by two drops of alkali-azide reagent. When precipitate settled, two drops of H_2SO_4 was added and the solution was mixed by inverting until dissolution was completed.

A volume corresponding to 100ml original sample after correction of the sample loss by displacement with reagents was titrated with 0.025M $Na_2S_2O_3$ to first disappearance of the colour using starch as indicator. The titration end points were recorded.

For Titration of 100ml sample, two drops of 0.025M $Na_2S_2O_3$ = 1mg DO/L

Acidity (mg/L)

Acidity of each water sample was determined using the Titration Method 2310B (APHA, 1998). A known amount of the sample was titrated against standard (0.02m) sodium hydroxide (NaOH) to p- and m- acidities, using Methyl orange as indicator. The titration end-point was recorded, and used to calculate the acidity of water samples as follow:

$$\boldsymbol{Acidity\ (mg/L) = \frac{Titre(ml) \times Molarity \times 50 \times 10^3}{Aliquot\ titrated\ (ml)}}$$

Biochemical Oxygen Demand (BOD) (mg/L)

This is the amount of dissolved oxygen that could be depleted from the water body during natural biological or degradation of organic compounds by the organisms presents especially bacteria. This is done after dissolved oxygen has been measured. Three standard 300ml bottles were filled to the brim with the water sample. In the first bottle, the Winkler Method was used to determine the amount of dissolved oxygen present. The other bottles were kept in the dark at 20^0C for five days. The Winkler Method was then used to determine the oxygen content of the bottles at the end of the five days and the average calculated.

The difference between this average and the initial concentration of the dissolved oxygen content of the first bottle is the Biochemical Oxygen Demand expressed in micrograms of oxygen per litre.

Chemical Oxygen Demand (COD) (mg/L)

The COD is determined by using the Closed Reflux Method 5220C with higher concentration of potassium dichromate solution. Most types of organics are oxidized by a boiling mixture of chromic and then titrated with Ferrous Ammonium Sulphate to determine the amount of $K_2Cr_2O_7$ consumed and the oxidisable matter is calculated in terms of oxygen equivalent. This was prepared by dissolving 4.903g $K_2Cr_2O_7$ (dried at 150^0C, 2hr.) in 500ml distilled water, followed by the addition of 167ml H_2SO_4 and 33.3g $HgSO_4$. The solution was allowed to cool before diluting to 100ml with distilled water. Each reaction tube washed with 20% H_2SO_4 before use.

Total Hardness (mg/L)

Total hardness of unfiltered water samples was determined by the Burette Titration Method. An aliquot of the test sample was titrated with standard 0.01M EDTA titrant with eriochrome black T as end-point indicator. The total hardness was:

$$\text{Total Hardness (mg/L as } CaCO_3) = \frac{\text{(Titre (ml) x 2500)}}{\text{Sample Volume (ml)}}$$

Chloride (mg/L)

Chloride was determined in unfiltered water samples by Burette Titration Method. An aliquot of the test sample was titrated with standard 0.014M silver nitrate titrant, with potassium chromate as end-point indicator. The chloride concentration was calculated as follows:

$$\text{Chloride (mg/L)} = \frac{\text{(Titre (ml) x 35450 x molarity of titrant)}}{\text{Sample Volume (ml)}}$$

Determination of Heavy Metals

Copper (mg/L)

This was determined using the Atomic Absorption Spectrophotometer (AAS). This is prepared by dissolving 0.0100g copper metal in 0.15ml HNO_3 (1+1) and diluting to 100ml [1.00ml = 0.1mg].

Iron (mg/L)

This was determined using the AAS. It was prepared by dissolving 0.0100g Iron wire in 5ml 1+1 HNO_3 and the diluting to 100ml with distilled water [1.00ml = 0.1mgFe].

Zinc (mg/L)
This was determined using the AAS. It was prepared by dissolving 0.0100g zinc metal in 2ml 1+1 HCl and then diluting to 100ml with distilled water [1ml=0.10mg Zn]. The values gotten are then expressed in mg/L.

Lead (mg/L)
This was determined using the Atomic Absorption Spectrophotometer (AAS). This is prepared by dissolving 0.0100g lead metal in 0.15ml HNO_3 (1+1) and diluting to 100ml [1.00ml = 0.1mg].

Cadmium (mg/L)
This was determined using the Atomic Absorption Spectrophotometer. It was prepared by dissolving 0.0100g cadmium wire in 5ml 1+1 HNO_3 and the diluting to 100ml with distilled water [1.00ml = 0.1mgCd].

Manganese (mg/L)
This was determined using the AAS. It was prepared by dissolving 0.0100g manganese metal in 2ml 1+1 HCl and then diluting to 100ml with distilled water [1ml=0.10mg Mn]. The values gotten are then expressed in mg/L.

Chromium (mg/L)
This was estimated using the AAS. It was prepared by dissolving 0.0100g chromium metal in 2ml 1+1 HCl and then diluting to 100ml with distilled water [1ml=0.10mg Cr]. The values gotten are then expressed in mg/L.

Nickel (mg/L)
This was determined using the AAS. It was prepared by dissolving 0.0100g nickel metal in 2ml 1+1 HCl and then diluting to 100ml with distilled water [1ml=0.10mg Ni]. The values gotten are then expressed in mg/L.

DETERMINATION OF CATION CONTENT

Calcium (Ca^{2+}) (mg/L)
The calcium content was estimated using the EDTA Titrimetric Method (APHA, 1998). The reagents used were Sodium Hydroxide, NaOH, Muxeride (Ammonium purpurate) as an indicator and a standard EDTA Titrant (0.01M). Sample preparation and titration was carried out immediately due to high pH of the medium. 0.5ml of 1ml NaOH or speck of NaOH crystal was added to 10ml of sample followed by a speck (0.1 – 0.2g) of calcium specific indicator mixture. The mixture was titrated with standard EDTA to the proper end point.

$$\text{Ca (mg/L)} = \frac{\text{A x B x 1000}}{\text{Vol. of sample (ml)}}$$

Where A = ml titrant for sample
B = mg Ca equivalent to two drops of EDTA titrant at the calcium indicate end Point.

Magnesium (Mg^{2+}) (mg/L)

The determination of Magnesium was estimated using the titrimetric method in a water sample diluting 1:000. The AAS was set in direct readout mode. A magnesium standard (0.5mg/L) was aspirated and used to set abundance to 0.5 units. The prepared samples were aspirated and the absorbance values noted (A) and all values expressed in mg/L.
Mg (mg/L) = Total hardness – Calcium concentration x 0.244.

DETERMINATION OF NUTRIENTS

Nitrate – Nitrogen (NO_3^-) (mg/L)

Nitrate concentration of each sample was determined using the Colorimetric Method 4500D (APHA, 1998) using an APHA/HACH DR 2010 Colorimeter with internal standard. The pH of the sample was first adjusted to acidic range by adding 2 drops of Hydrochloric acid (HCl) to 25ml of the filtered sample. A drop of NED reagent was then added to the mixture and allowed to stand for 5-10 minutes before being tested for nitrate with the colorimeter at 543nm. All readings were recorded in mg/L.

Phosphate - Phosphorus (PO_4^-) (mg/L)

This was determined using the Colorimetric Method (Stannous Chloride Method 4500-PD). Molybdophosphic acid is formed and reduced by stannous chloride to intensely coloured molybdenum blue which absorbs at 625 – 690nm. 10ml sample was acidified with dilute H_2SO_4. 1ml of ammonium molybdate reagent and 0.5ml stannous chloride reagent was added, mixed and allowed to stand for 5mins. The colour is determined at 650nm phosphate concentration was then read off the display. The colorimeter was previously calibrated with phosphate standards before use. All readings were expressed in mg/L.

Sulphate (mg/L)

This was determined using the Turbidimetric Method 4500E (APHA, 1998). 10ml of the sample was mixed with 10 drops of already prepared conditioning reagent and then mixed. A pinch of Barium chloride ($BaCl_2$) salt was added and the solution left standing for 5min. A colorimeter, previously calibrated with sulphate standards was used to read the sulphate concentration in each sample and the readings expressed in mg/L.

Silica (S_iO_2) (mg/L)

The Silica was measured using a colorimeter. To 10ml of the sample was added 0.2ml Hydrochloric acid (HCL) followed by 0.4ml molybdate reagent. The mixture was allowed to stand for 5min and 0.4ml of an already prepared reducing solution was added. Silica concentration was determined at 600nm using a pre-calibrated colorimeter (DR2010) and the readings expressed in mg/L.

Dissolved Inorganic Nitrogen (DIN) (mg/L)

A portion of the sample was filtered through a 0.45µm Glass Fiber filter. The filtrate was used for the determination of DIN (NO_3-N, NO_2-N, and NH_3-N). Nitrate-nitrogen was determined on 10 ml aliquot by cadmium reduction method (HACH Method 8039), with NitraVer-5 reagent powder. Test solutions were measured at 500nm using HACH DR 3900 spectrophotometer. Nitrite-nitrogen was determined on 10 ml aliquot by diazotization using NitriVer 3 reagent powder (HACH Method 10019). Test solutions were determined at 507nm, using HACH DR 3900 spectrophotometer. Ammonia-nitrogen was determined by the salicylate method using AmVer reagent powder, on 10ml aliquot. Test solutions were measured at 655 nm (HACH Method 8155). The concentration of dissolved inorganic nitrogen (DIN) is the sum of NO_3^-N, NO_2-N, and NH_3-N. The concentrations of dissolved organic nitrogen (DON) were estimated by subtracting DIN from TDN.

Total Dissolved Nitrogen (TDN) (mg/L)
A 2ml aliquot of the filtered sample was used for the determination of Total Dissolved Nitrogen (HACH Method 10072), following an alkaline per sulphate digestion, at 105 °C for 30min, which converts all forms of nitrogen to nitrate. Nitrate then reacts with chromotropic acid under strongly acidic conditions to form a yellow complex, in proportion to the TDN concentration. The test solution was measured at 410nm.

Dissolved Organic Nitrogen (DON) (mg/L)
DON was the determined by difference
DON = TDN – DIN (by difference)
Where;
TDN is Total Dissolved Nitrogen after per sulphate oxidation
DIN is the sum of the Dissolved Inorganic Nitrogen species.

Dissolved Inorganic Phosphate - Reactive Phosphorus (Orthophosphate) (mg/L)
A portion of the sample was filtered through a 0.45µm Glass Fiber filter. The filtrate was used for the determination of DIP (as PO_4). A 10ml aliquot of the filtrate was reacted with molybdate in an acid medium (PhosVer3 reagent powder, HACH Method 8048) to produce a mixed phosphate/molybdate complex. Ascorbic acid in the reagent then reduces the complex to an intense blue color which is proportional to the phosphate concentration. Measurement was made at 880nm, using a HACH DR 3900 spectrophotometer.

Oil and Grease (mg/L)
A 100ml aliquot of the water sample was acidified to $pH < 2$ and then extracted three times with 15ml hexane in a separator funnel. The combined extract was dried by filtering through 1g of sodium sulfate, and then diluted to 20ml in a volumetric flask. Oil & Grease was determined by IR spectroscopy (EPA Method 418.1), following an ejection of 50µL of the extract unto the plate of the Total Oil & Grease Analyzer (InfraCal-2).
A calibration working solution (1-10mg/mL total OG) was used to validate the method.

RESULTS/FINDINGS

Physicochemical Parameters,

Water Temperature (°C)

The Water temperature values fluctuated as in the air temperature at all stations during the period of study and ranged from 23 to 29.5°C. Station 2 recorded the lowest value in July. Station 1 recorded the highest value in September

Total Suspended Solids (mg/L)

There were considerable variations in the TSS values recorded across the stations during the period of study and it ranged from 9 to 43mg/L. Station 1 recorded the lowest TSS value in July. Station 2 recorded the highest value in June.

Total Dissolved Solids (mg/L)

Total Dissolved Solids values fluctuated significantly from 386.3mg/L-15700mg/L across the stations during the period of study. In June, Stations 2 and 1 recorded the lowest TDS value and the highest value respectively.

Turbidity (NTU)

There was slight variation in the turbidity values from 4.92NTU to 34.02NTU across the three stations all through the period of study. Station 1 recorded the lowest value in June. Station 3 recorded the highest value in August.

pH Value

pH values varied between low acidic and low alkaline. The lowest value (6.9) was recorded in May at Station 2 while the highest value (7.3) was recorded in August at Station 3.

Acidity (mg/L)

The acidity values varied significantly from 14.9 mg/L- 155.4mg /L across the three stations during the period of study. Station 1 recorded the lowest acidity value of in June while Station 2 recorded the highest acidity value in September.

Alkalinity (mg/L)

The alkalinity values varied widely from 82mg/L- 769mg/L across the three stations during the period of study. Station 1 recorded the lowest alkalinity value in the month of September while Station 2 recorded the highest alkalinity in July.

Salinity (%o, at 25ºC)

The salinity values varied slightly from 0.53% - 8.9% across the three stations all through the period of study. Station 2 recorded the lowest value in June. Station 1 recorded the highest value in August.

Conductivity (µS/cm)

Conductivity values also varied widely from 679.3µS/cm- 25900µS/cm across the three stations all through the period of study. In June, Stations 2 and 1 recorded the lowest value and the highest value respectively.

Dissolved Oxygen (mg/L)

The values of Dissolved Oxygen (DO) varied slightly from 0.1mg/L- 4.8mg/L across the three stations all through the period of study. Station 2 recorded the lowest DO value in August. Station 1 recorded the highest value in June, the values decreased slightly in July and August and decreased significantly in September. There were significant decreases in value in other stations.

Biochemical Oxygen Demand (mg/L) The Biochemical Oxygen Demand (BOD_5) values fluctuated from 2mg/L- 598mg/L across the stations during the period of study. Station 3 recorded the lowest BOD_5 value in September while Station 2 recorded the highest BOD_5 value in August.

Chemical Oxygen Demand (mg/L)

The Chemical Oxygen Demand (COD) values varied widely from 10mg/L - 2192mg/L across the stations during the period of study. Station 3 recorded the lowest COD value in September. Station 2 recorded the highest COD value in July.

Total Hardness (mg/L)

The value of Total Hardness (TH) varied widely from 82mg/L- 2972mg/L across the stations all through the period of study. Station 2 recorded the lowest TH value in August and Station 1 recorded the highest TH value in June.

CATION CONTENT

Potassium

Potassium values varied significantly from 3.62mg/L- 151mg/L across the stations all through the period of study. In June, Stations 2 and 1 recorded the lowest and highest potassium values respectively.

Calcium

Calcium values varied from 4.11mg/L- 170.3mg/L across the stations all through the period of study. In June, Stations 2 and 1 recorded the lowest and highest calcium values respectively.

Silica

Silica value ranged between 0.82mg/L - 11.43mg/L from across the three stations all through the period of study. Station 3 recorded the lowest and highest silica values in September and June respectively.

Sodium

Sodium value varied significantly from 135.1mg/L -4926.07mg/L across the three stations all through the period of study. In June, Stations 2and 1 recorded the lowest and highest Sodium values respectively.

Oil and Grease

The Oil and grease value recorded were uniform (< 0.2 mg/L) across the three stations all through the period of study.

NUTRIENTS

Data for these are presented graphically in Figures 2 - 6

Reactive Nitrogen (NO_3 - N)

The nitrate values varied from 1.9mg/L - 4.53mg/L across the three stations all through the period of study. Station 1 recorded the lowest nitrate value in August. Station 3 recorded the highest nitrate value in May.

Reactive Phosphorus (PO_4 - P)

The Phosphate values recorded varied from 0.3mg/L-9.08mg/L across the stations during the period of study. In July, Stations 1 and 2 recorded the lowest and highest phosphate values respectively.

Sulphate (SO_4^{2-})

The Sulphate values recorded from 27.2 mg/L – 1094mg/L across the stations varied significantly all through the period of study. In June, stations 2 and 1 recorded the lowest and highest sulphate values respectively.

Dissolved Inorganic Phosphate (DIP)

The DIP value varied between 0.1mg/L - 3.033mg/L. In July, Stations 1 and 2 recorded he lowest and highest values respectively.

Dissolved Inorganic Nitrogen (DIN)

The DIN values varied between 0.336 to 1.023mg/L. Station 1 recorded the lowest value in August. Station 3 recorded the highest value in May

Dissolved Organic Nitrogen (DON) The DON values varied and ranged between 0.126 to 3.108mg/L. Station 1 recorded the lowest value in September. Station 3 recorded the highest value in June.

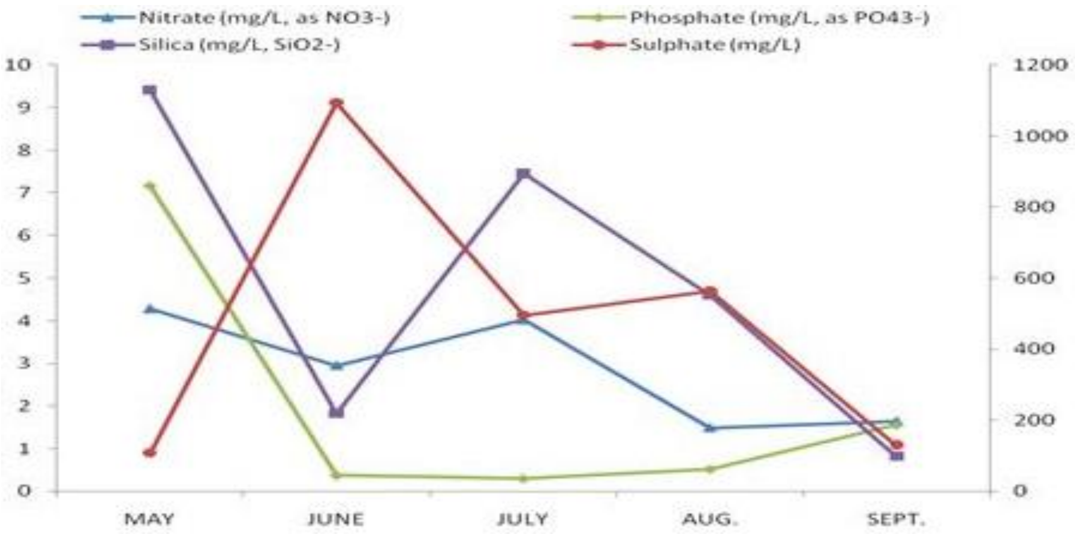

Figure 2: Monthly variation in Nitrate, Phosphate, Silica and Sulphate for Station 1 at the Ajegunle Creek.

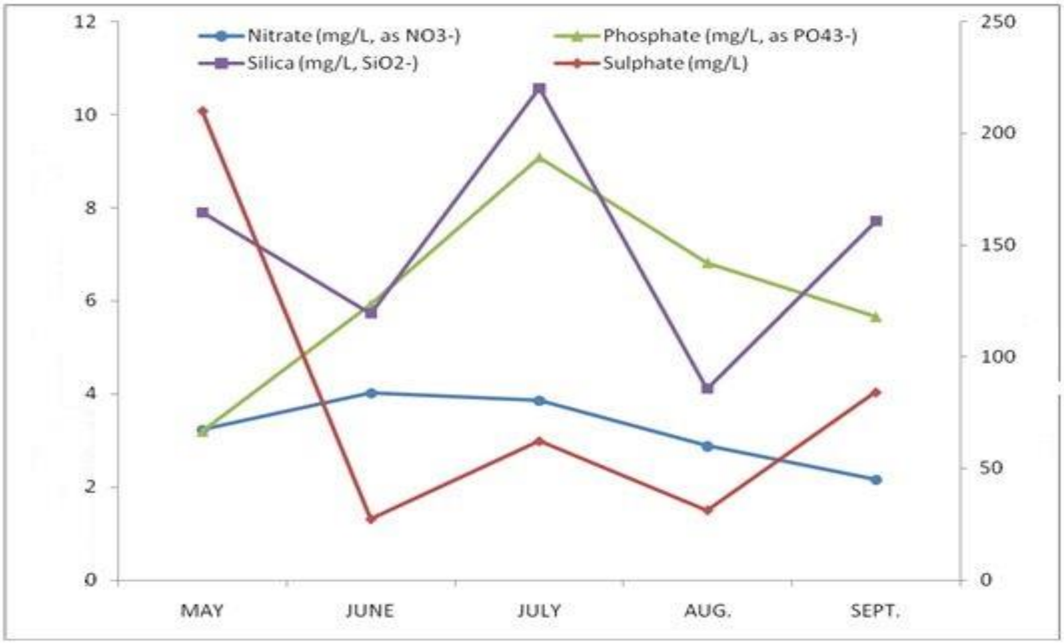

Figure 3: Monthly variation in Nitrate, Phosphate, Silica and Sulphate for Station 2 at the Ajegunle Creek.

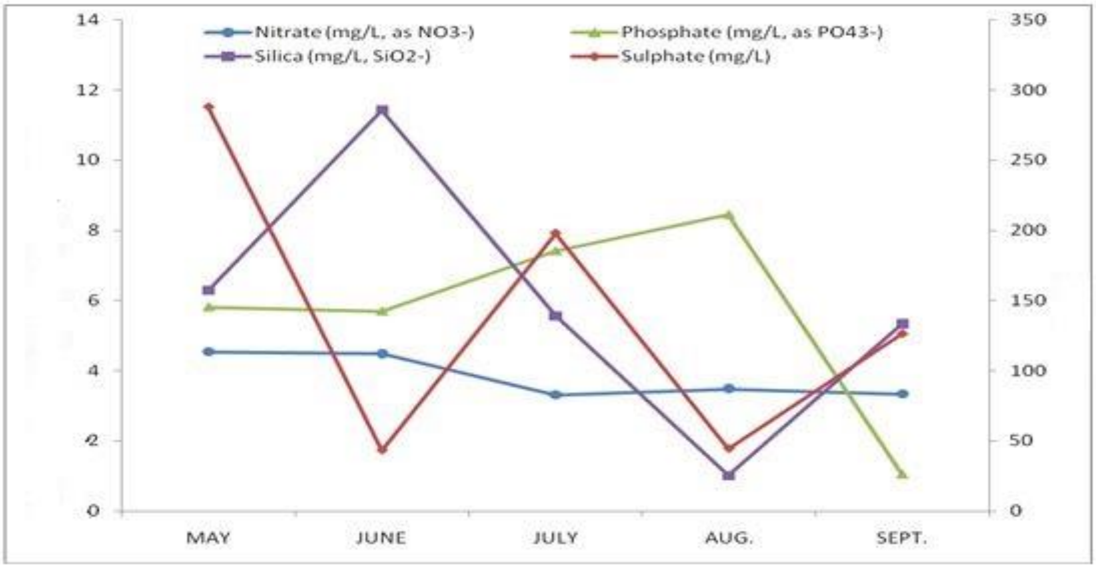

Figure 4: Monthly variation in Nitrate, Phosphate, Silica and Sulphate for Station 3 at the Ajegunle Creek.

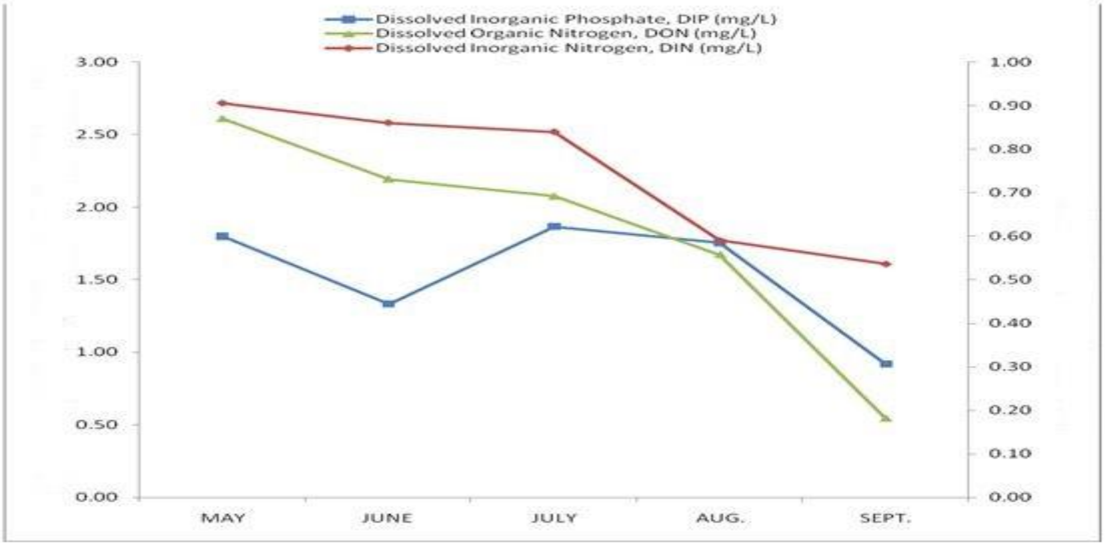

Figure 5: Monthly variation in Dissolved Inorganic Phosphate, Dissolved Inorganic Nitrogen and Dissolved Organuc Nitrogen at the Ajegunle Creek .

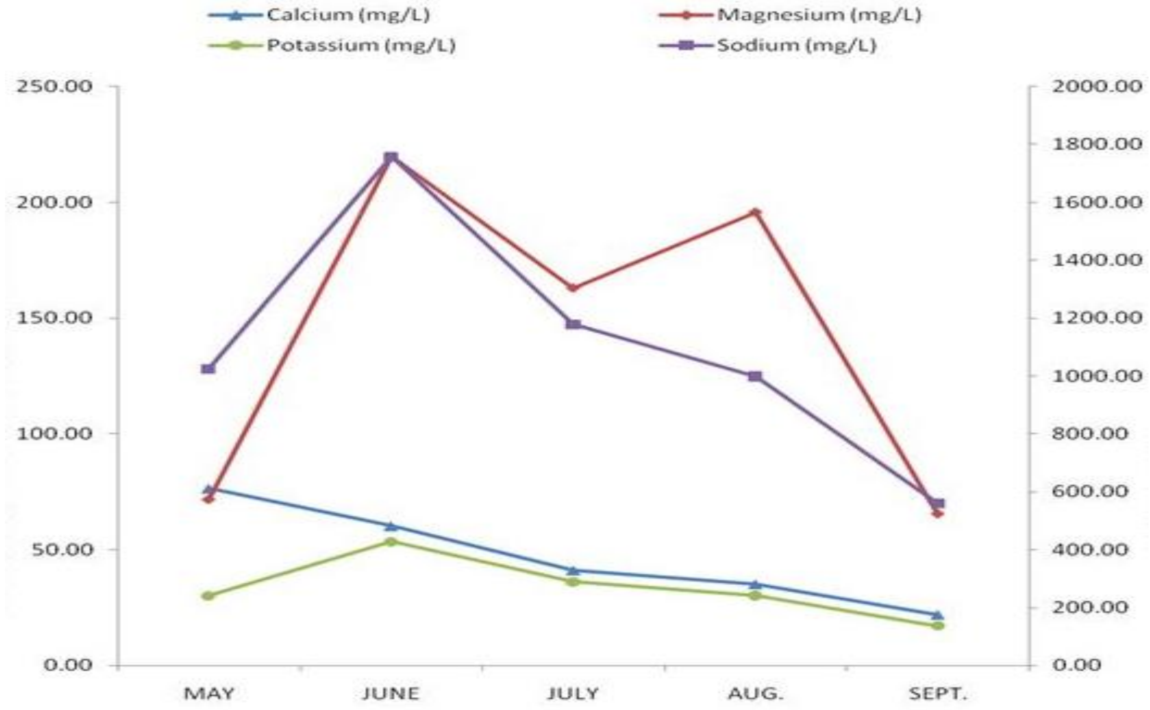

Figure 6: Monthly variation in Calcium, Sodium, Magnesium and Potassium at the Ajegunle Creek .

HEAVY METALS

Data for the Heavy Metals are presented graphically in Figures 7 - 9

Lead

The values of Lead recorded varied between 0.0007mg/L to 0.0016mg/L across the stations during the period of study. Station 3 recorded the lowest value in May and Station 2 recorded the highest value in August.

Chromium

The Chromium values recorded ranged between 0.0006mg/L to 0.0027mg/L during the period of study. Station 1 recorded the lowest value in September. Station 2 recorded the highest value in August.

Copper

The Copper values recorded varied minutely and ranged between 0.0003mg/L to 0.0011mg/L across the stations all through the period of study. Station 1 recorded the lowest value in May. Station 2 recorded the highest values both in June and August.

Iron

Iron values recorded ranged between 0.11mg/L to 0.424mg/L across the stations all through the period of study. Station 2 recorded was the lowest value in August. Station 3 recorded the highest value in June.

Zinc

The Zinc values recorded varied and ranged between 0.019mg/L to 0.397mg/L across the stations all through the period of study. Station 3 recorded the lowest value in September. Station 2 recorded the highest value in August.

Cadmium

Cadmium values varied minutely across the stations all through the period of study and ranged between 0.0005mg/L to 0.0016mg/L. Stations 1 and 3 recorded the lowest value in September. Station 2 recorded the highest value in June and July.

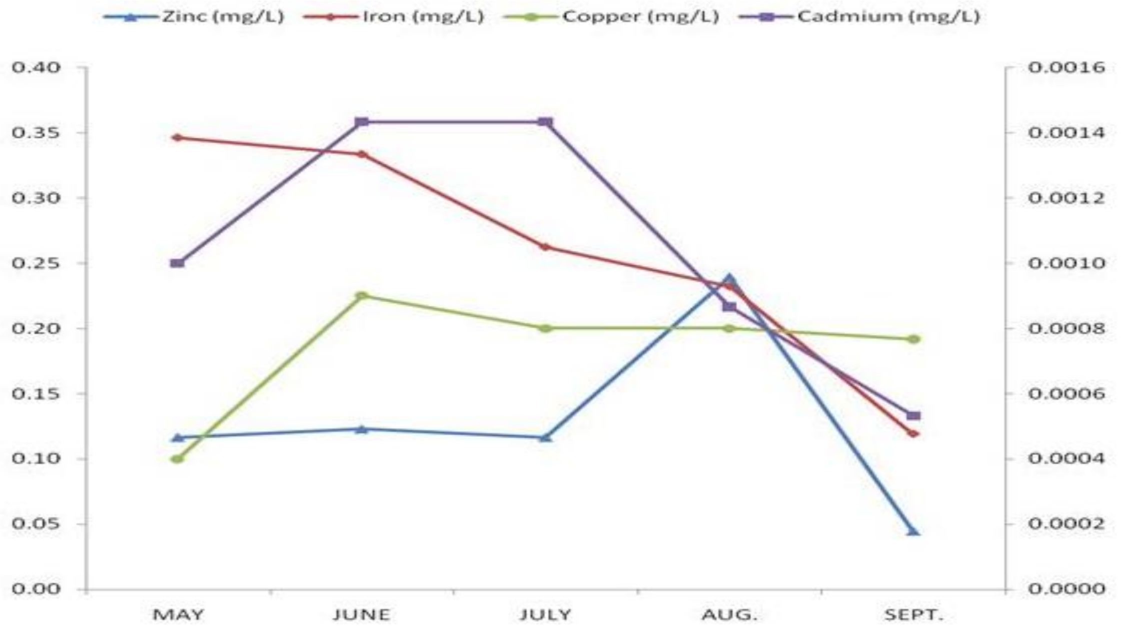

Fig. 7: Monthly variation in Zinc, Iron, Copper and Cadmium at the Ajegunle Creek

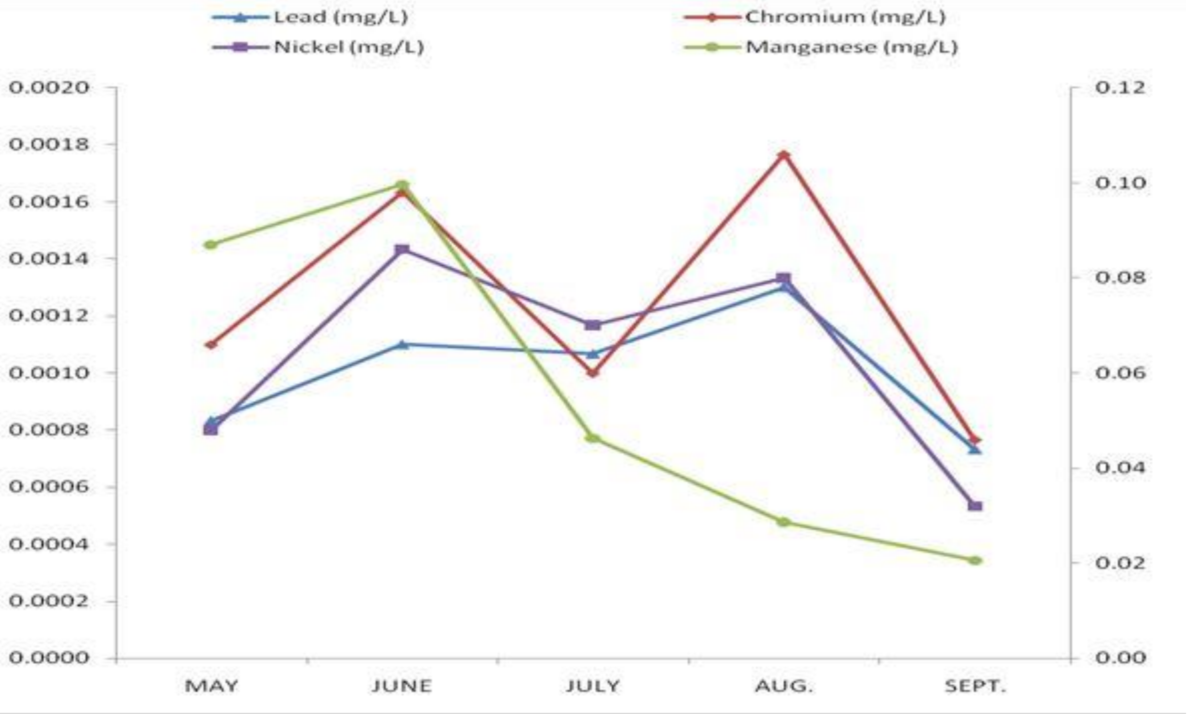

Fig. 8: Monthly variation in Manganese, Lead, Chromium and Nickel at the Ajegunle Creek.

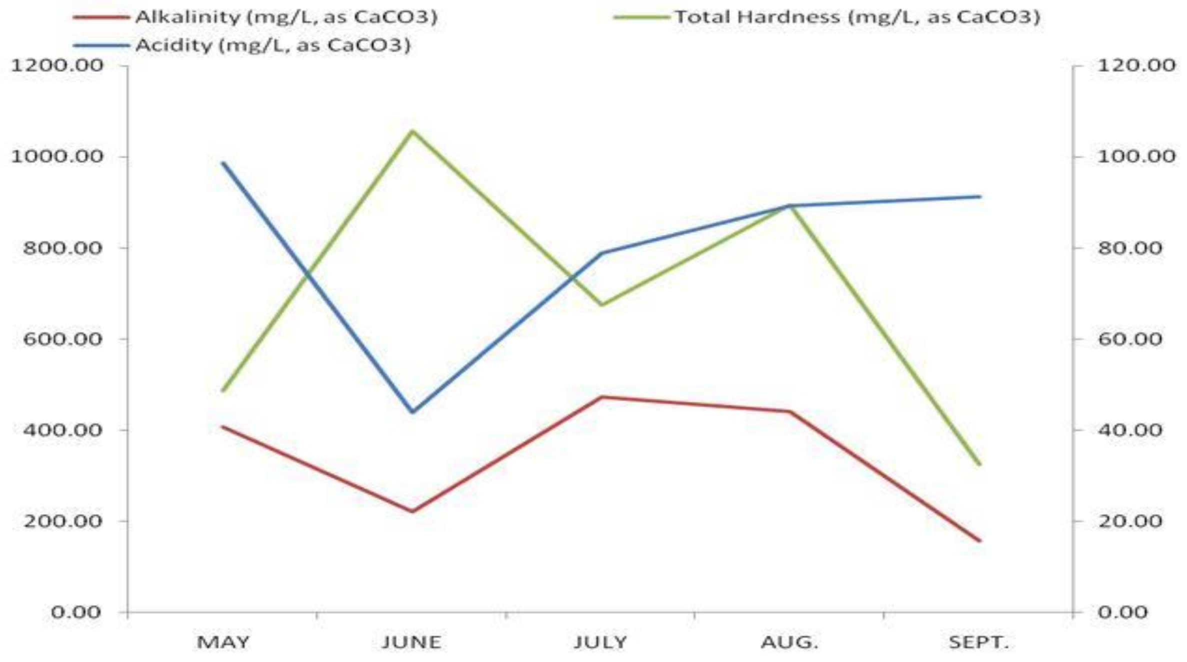

Fig. 9: Monthly variation in Total Hardness, Acidity and Alkalinity at the Ajegunle Creek.

DISCUSSION

The gradients observed in water quality of the three sampled stations from during the period of study suggested that chemical characteristics and physical processes are factors that play an important role in promoting changes in the water body (Jarvis, 2007). The physico-chemical parameters observed at the Ajegunle Creek showed seasonal changes from those reported by past researchers who had worked and explained that the distributive pattern of the water body of a region, characterized by low physico-chemical parameters and increased nutrient levels of the water are responsible for the ever-vibrant seasonal and spatial changes in the phytoplankton biomass and community (Abowei, 2010). The prevailing and fluctuating physicochemical parameters may affect the nutrients' availability which may result in reduction of the abundance, distribution and diversity of the plankton in the creek (Dogipatri *et al.,* 2013). This shows an indication that the water quality is deteriorating at an alarming rate.

The assessment of nutrient levels showed variations which could be attributed to several factors. Nitrate ion is the common form of nitrogen found in natural waters. The recorded nitrate ion at the studied areas was within the acceptable limit (WHO, 2011). However, the high level of nitrate recorded in May could be attributed to poor sanitation, probably leaching of nitrates from the nearby pit latrines, animal sewage, use of fertilizer, seasonal influence of biomass burning that are washed during onset of rainfall. From the study, it could be concluded that the level of decrease in nitrate with increase in rainfall and the low level of nitrate could be due to high dilution of faecal matter by rain water and surface runoff or selective removal of nitrates and chlorides during transport in the soil (Akintola *et al.*, 2011). Natural level of nitrate in surface water seldom exceeds 0.1mg/L as, but waters influenced by human activity normally contain up to 5mg/L as with levels over 5mg/L as N indicating pollution by animal or human waste or fertilizer runoff as reported by (Lewis *et al.,* 1980). This was in line with the submission of Nwankwo and Akinsoji (1989) that the Lagos lagoon is under intense pressure from pollution such as untreated sewage, sawdust, petrochemical materials, detergent and industrial effluents.

The metals concentrations recorded during the period of study are arranged in order of their distributions in the three sampling stations as follows: Fe>Zn>Mn>Cr>Ni>Cd>Pb>Cu. The high levels of heavy metals obtained in the studied Creek could probably be associated with the following activities such as sewage, cement bags washing, domestic and industrial wastes that took place within and around the Creek. The biological and toxic roles of metals have been studied extensively in recent years. Jadhey *et al.* (2010) reported that heavy metals are diluted and affected by various surface water components (carbonate, sulphate, organic compounds) that formed insoluble salts or complexes. These salts and its complexes are predicted not to be harmful to aquatic organisms but part of them sink and are accumulated in bottom sediments (Arain *et al.*, 2008). However, when there is a decline in the pH, heavy metals can be mobilized and released into the water column and become toxic to aquatic biota.

CONCLUSION

It may be necessary to conclude that the Ajegunle Creek of the Lagos lagoon is a polluted creek which could be attributed to the observed variation in the parameters which could be related to anthropogenic activities. The study stations which show that the major pollutants were more than just organic based pollutants but may also be as a result of other anthropogenic activities going around the creek like the high rate of pollution from surrounding residents which is evident by the large amount of refuse deposited at the banks of the creek and sewage floating on the water surface into which toilets and bathrooms have been constructed.

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